Unmixing of ferrobasaltic melts: evidence from centrifuge and static experiments

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Immiscibility between Fe-rich and silica-rich melts have been reported in lunar and terrestrial basaltic glasses [1], and reproduced in laboratory experiments. An unusual case of high-temperature immiscibility at T>1150 °C has been documented in glassy melt inclusions in native iron on Disco island, West Greenland, and in the Siberian trap province [2]. Our attempts to reproduce the unmixing experimentally in 1-atm gas mixing furnaces at temperatures 1098-1320 °C and log fO_2 from –7.8 to –12.1 were unsuccessful leading to crystallisation of tridymite from homogenous melt at only 53.3 wt.% SiO_2. We interpret tridymite as metastable substitute for silica-rich immiscible liquid, and conclude that unmixing of ferrobasaltic liquids can be seriously hampered by nucleation problems.

The unmixing was however achieved at 1200 °C and fO_2 close to the IW buffer in a furnace mounted on a centrifuge at acceleration of 9800 m/s^2. At maximal run durations allowed by the equipment (3-4 hours), phase segregation was incomplete, and small amounts of tridymite were still present. Nevertheless, centrifuge pool certainly helped to overcome the nucleation barrier, and assisted liquid immiscibility.

We applied the same centrifuge method to the liquid composition from the Middle Zone of the Skaergaard intrusion previously constrained by static experiments at 1-atm FMQ buffer and 1100-1120 °C [3]. Liquid immiscibility was not observed in the static runs. However, in centrifuge experiments at 1120 °C, the same ferrobasaltic liquid (50% SiO_2 and 17.2% FeOt) produced a thin, top layer of silica-rich immiscible liquid (64.5% SiO_2 and 7.4% FeOt). Silica content in the main Fe-rich liquid consequently dropped to 46%, while the content of FeOt increased to 21%.

Our results imply that liquid immiscibility in Skaergaard is likely already at the transition from the Lower to the Middle Zone. From that stage, immiscibility should have profound effects on magma dynamics. It may explain the origin of some types of layering, and help to resolve other long-standing problems of Skaergaard magma evolution.

References

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